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Revision of *Termitomyces* in China

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Abstract — A survey of *Termitomyces* was carried out to clarify the species in China based on examination of more than 600 specimens, of which one third were fresh material collected from the field in this study. Among 32 Chinese records, including 26 in *Termitomyces* and six in *Sinotermitomyces*, the distribution of 11 species in China, viz. *T. aurantiacus*, *T. bulborhizus*, *T. clypeatus*, *T. entolomoides*, *T. eurrhizus*, *T. globulus*, *T. heimii*, *T. mammiformis*, *T. microcarpus*, *T. striatus* and *T. tylerianus*, is recognized, whilst seven are excluded because of misidentification or misapplied names, and five are unconfirmable owing to the lack of specimen support. There are nine synonyms of other known *Termitomyces* species, eight of which were described as new species from China. The recognized Chinese species are described in detail with discussion on their morphological variation. A key to the Chinese species is provided and discussion on other Chinese records made.

Keywords — *Agaricales*, taxonomy, *Lyophyllaceae*

Introduction

Termitomyces is an agaric genus cultivated by termites, with basidiomata growing in association with termite nests. The relationship between *Termitomyces* and termites is mutualistic or symbiotic (Batra & Batra 1966, 1967, 1979, Batra 1975, Heim 1977, Bels & Patarageti vit 1982, Shaw 1992). The colonies of *Termitomyces* are managed by termites in their nest as "fungus gardens" and in return the fungi degrade lignin and cellulose of plant material for termites as food. In addition, *Termitomyces* fungi also provide other substances, e.g. enzymes and vitamins that are vital to the life of termites (Batra & Batra 1967, 1979). Species of *Termitomyces* are edible and sought after (Oso 1975, Parent

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& Thoen 1977, Ogundana & Fagade 1981, Purkayastha 1985, Sangvichien & Taylor-Hawksworth 2001) and highly priced in the markets, e.g. US$6.5/kg in local markets of Chiang Mai, Thailand in 1994 (Jones et al. 1994) and US$25/kg (RMB¥200/kg) in Kunming, Yunnan, China in 2006 (this study).

Termitomyces is a monophyletic clade in *Agaricales* (Moncalvo et al. 2000, Aanen et al. 2002, Rouland-Lefevre et al. 2002, Frøslev et al. 2003) and should be placed in *Lyophyllaceae* Jülich based on molecular phylogenetic analyses (Matheny et al. 2007). *Termitomyces* is also very distinct for its symbioses and co-evolution with species of *Macrotermitinae* Kemner (*Isoptera*). About 330 termites can establish symbiotic relationships with *Termitomyces* species (Mueller & Gerardo 2002), mainly *Macrotermes* Holmgren, *Microtermes* Wasmann and *Odontotermes* Holmgren (Batra & Batra 1966, 1979, Batra 1975, Heim 1977, Zang 1981a, Thomas 1985). In recent studies, it was determined that the fungus-growing termites originated in African rainforests (Aanen & Eggleton 2005) and that termite-*Termitomyces* symbiosis is also of single African origin (Aanen et al. 2002).

Currently, 81 names based on 68 taxa have been published under *Termitomyces* worldwide, of which 40 were accepted in the Dictionary of the Fungi (Kirk et al. 2001). The genus is distributed widely from equatorial and southern Africa to southern and southeastern Asia, including southern China (Heim 1942, 1977, Otieno 1966, 1969, Pegler 1977, Batra & Batra 1979, Van der Westhuizen & Eicker 1990, Pegler & Vanhaecke 1994, Wei & Yao 2003). The species, with few exceptions, can be easily recognized by their prominent perforatorium, long subterranean pseudorhiza, pinkish basidiospore deposit and non-amyloid basidiospores (Heim 1942, 1977, Pegler 1977). Compared with other agarics, the genus has a wide range of morphological differentiation among species. *Termitomyces titanicus* Pegler & Piearce, for example, forms the largest agaric basidiomata in the world with a pileus more than 1 m diam. (Piearce 1987), whilst that of *T. microcarpus* rarely exceeds 2.5 cm diam. (Heim 1977, Pegler & Vanhaecke 1994).

Since *Termitomyces* was proposed by Heim (1942), numerous taxa have been documented from Africa (e.g. Heim 1941, 1942, 1951, 1952, 1958, Otieno 1966, 1969, Reid 1975, Pegler 1977, Pegler & Piearce 1980, Van der Westhuizen & Eicker, 1990, Saarimäki et al. 1994, Mossebo et al. 2002) and the research on Asian species has also been carried out by Natarajan (1976, 1977, 1979), Sathe & Daniel (1981), Sathe & Deshpande (1981), Natarajan & Raman (1981), Natarajan & Purushothama (1986), Dhancholia et al. (1991), Pegler & Vanhaecke (1994), Wei & Yao (2003), Wei et al. (2003, 2004, 2006) and Tang et al. (2006a, b). There are five species of *Termitomyces* reported from Central America (Gómez 1995), but their taxonomic status remains uncertain because

the region is obviously beyond the established distribution of *Macrotermitinae* species.

The generic status of *Sinotermitomyces* was queried by Pegler & Vanhaecke (1994) and Frøslev et al. (2003) based on either morphological or molecular evidences. Five species of *Sinotermitomyces* (including type species, *S. cavus*) have proved to be synonyms of *Termitomyces* species based on the study of their type material and the two genera are confirmed as congeneric (Wei et al. 2006).

Termitomyces species in China was first reported by Cheo (1942) under the name "*Collybia albuminosa* (Berk.) Petch" (Wei & Yao 2003) and further description of the genus was then provided by Teng (1963) in Chinese. *Termitomyces* species with correct generic name were first recorded from Fujian by Huang (1973), and then Zang (1981a) reported three species from Yunnan, including two new records. Subsequently, more *Termitomyces* taxa, with four new species, were reported by He (1985), Zhang & Ruan (1986), Yang (1990), Yang & Shuai (1990), Ying & Zang (1994), Yuan & Sun (1995), Mao (2000), Wang & Liu (2002) and Wei et al. (2004). To clarify *Termitomyces* species in China, all specimens of the genus deposited in major Chinese fungal herbaria were examined and additional specimens were collected from field work over recent years. The results of this study are reported here. Eleven species of *Termitomyces* are recognized from China and fully described with comments on their identification and distribution in this paper. Conclusions on the previously reported taxa (including six *Sinotermitomyces* species) are also summarized, together with provision of a key to the recognized species in China.

Materials and methods

More than 400 specimens of *Termitomyces* species deposited in three fungal herbaria in China, i.e. the Fungal Herbarium, Institute of Microbiology, Chinese Academy of Sciences (also as Herbarium Mycologicum Academiae Sinicae, HMAS), the Herbarium of Cryptogams, Kunming Botanic Institute, Chinese Academy of Sciences (HKAS) and the Herbarium of Institute of Microbiology, Guangdong (HIMGD), representing almost all the collections of the genus in China, were examined. In addition to the existing exsiccata, extensive field work was carried out by this group from 2002 to 2005 and more than 200 fresh collections of the genus were obtained and used for this study.

The fresh basidiomata were carefully examined by removing the soil on the surface of pseudorhiza and the macro-morphological characters were recorded in detail before oven drying at about 45°C. Tissue preservation in silica gel and living strain isolation were also performed in the field for molecular work and

for other further studies (results not reported here). The microscopic characters of all the dried specimens were examined. Thin sections were prepared by hand, using a razor-blade. The sections of dried basidiomata, including lamellae, cutis, pileal context and partial veil, were mounted in 5 % KOH solution. Size range of basidiospores, basidia, tramal hyphae, pileal context and cutis were measured using an ocular micrometer. At least 30 basidiospores and 20 basidia of each mature specimen were measured.

Descriptions of the specimens on loan from herbaria were mainly based on the dried material including the original collection records. Some herbarium specimens were in bad condition and the species identity could not be determined. They are not cited in this paper.

Taxonomy

Termitomyces R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 147 (1942).

= *Rajapa* Singer, Lloydia 8: 142 (1945) (see Singer 1946).

= *Podabrella* Singer, Lloydia 8: 143 (1945) (see Pegler 1977, Gomez 1995).

= *Sinotermitomyces* M. Zang, Mycotaxon 13: 171 (1981) (see Wei et al. 2006).

Type: *Schulzeria striata* Beeli, Bull. Jard. Bot. État. 15: 29 (1938).

Basidiomata small to large. Pileal surface white to colored, usually paler toward margin; smooth or coarse, squamulate or smooth, rimose radially; margin striate, often splitting radially when mature, usually with protruding perforatorium, but absent or indistinct in a few species. Lamellae free, white at first, becoming cream or pinkish when mature; crowded, with lamellulae. Stipe central, usually cylindrical and more or less thickening close to the ground; surface white, smooth or squamulate; annulate or not; solid, fibrous, consisting of longitudinally parallel thin-walled hyphae. Pseudorhiza mostly present, rarely absent; tapering or cylindrical, connected to termite combs; surface pale or dark colored, striate; solid or hollow, fibrous, leathery or cartilaginous. Partial veil present or not, membranous if present; ephemeral in most species, and sometimes persisting as an annulus and squamules. Context white, fleshy, of thin-walled, inflated hyphae. Basidiospore deposit pinkish or cream. Basidiospores ovoid to ellipsoid; surface smooth; thin-walled and subhyaline; inamyloid. Basidia clavate, thin-walled and subhyaline with 4 sterigmata. Cystidia present or not, usually clavate to pyriform, few fusiform; rarely septate; smooth; thin-walled and hyaline. Clamp-connections absent.

In addition to 24 taxa previously reported from China (Wei & Yao 2003), one new species, *T. bulborhizus*, and one new Chinese record, *T. entolomoides*, were reported during this investigation (Wei et al. 2003, 2004). A total of 26 taxa of *Termitomyces* have been reported from China and another six were

described under *Sinotermitomyces*. All of these taxa are listed in Table 1 with their current status indicated. There are 11 species recognized in China with nine synonyms, seven excluded because of misidentification or misapplied name, and five unconfirmed records owning to the lack of specimen support. The recognized species are described below and included in the key, whilst the records of synonyms and of misapplied names are discussed under their correct names.

Key to *Termitomyces* species recognized in China

1a. Basidioma small, with pileus less than 4.5 cm diam. when mature 2
1b. Basidioma medium to large, with pileus more than 4.5 cm diam. when mature... 3

2a. Basidioma growing from debris of comb carried to ground surface by termites, without pseudorhiza; pileus with small and bluntly pointed perforatorium ..... ***T. microcarpus***
2b. Basidioma arising from comb surface, with elongated pseudorhiza; pileus with sharply pointed perforatorium ..... ***T. tylerianus***

3a. Basidioma medium-size, pileus usually less than 10.0 cm diam.; pseudorhiza surface white, cream or pale greyish 4
3b. Basidioma large, pileus usually more than 12.0 cm diam.; pseudorhiza surface pale or dark colored 9

4a. Partial veil forming persistent, double-ringed annulus plus squamules on both pileal and stipe surface; pseudorhiza hollow, leathery 5
4b. Partial veil none or ephemeral, forming neither an annulus nor persistent squamules; pseudorhiza solid, fibrous 6

5a. Perforatorium obtuse, coarse but non-scrobiculate ..... ***T. heimii***
5b. Perforatorium mammiform, scrobiculate or alveolate..... ***T. mammiformis***

6a. Pileal surface black; stipe surface pale grey, with fine flocci ..... ***T. entolomoides***
6b. Pileal surface white to brown; stipe surface white, smooth and glabrous..... 7

7a. Perforatorium distinctly pointed, sharp spiniform ..... ***T. clypeatus***
7b. Perforatorium only moderately pointed 8

8a. Pileal surface bright, golden, orange to reddish brown ..... ***T. aurantiacus***
8b. Pileal surface white, or cream to greyish white..... ***T. striatus***

9a. Stipe surface with persistent flocci, with a bulbous base; pseudorhiza pale, pale yellowish or pale brownish ..... ***T. bulborhizus***
9b. Stipe surface smooth and glabrous, base thickening but non-bulbous; pseudorhiza dark, brown, reddish brown or black..... 10

10a. Perforatorium bluntly pointed or obtuse; pileal margin straight to upcurved when mature; pseudorhiza covered by a black crust, cartilaginous ..... ***T. eurrhizus***
10b. Perforatorium absent; pileal margin incurved or downwardly curved when mature; pseudorhiza brown or reddish brown ..... ***T. globulus***

Table 1. *Termitomyces* and *Sinotermitomyces* taxa reported from China.

Taxa	References	Current status
Termitomyces albiceps	He (1985)	Synonym of *T. eurrhizus*
T. albuminosus (Berk.) R. Heim	Huang (1973)	*, synonym of *Leucocoprinus cepistipes*, misapplied to Chinese records, which possibly belong to *T. eurrhizus* or *T. clypeatus*
T. aurantiacus	Yang & Shuai (1990)	√
T. badius	Zhang & Li (1988)	Synonym of *T. microcarpus*
T. bulborhizus	Wei et al. (2004)	√
T. clypeatus	He (1985)	√
T. cylindricus	He (1985)	Synonym of *T. aurantiacus*
T. entolomoides	Wei et al. (2003)	√
T. eurrhizus	Bi (1986)	√
T. fuliginosus R. Heim	Zhang & Li (1988)	*, misidentification of *T. clypeatus* or *T. eurrhizus*
T. globulus	He (1995)	√
T. heimii	Yang (1990)	√
T. letestui (Pat.) R. Heim	Mao (2000)	*, without specimen support and the description does not coincide with that of Heim (1942)
T. macrocarpus	Zhang & Ruan (1986)	Synonym of *T. eurrhizus*
T. mammiformis	Mao (2000)	√
T. mammiformis f. *albus* R. Heim	Mao (2000)	**
T. medius R. Heim & Grassé	Bi et al. (1994)	*, misidentification of *T. microcarpus*
T. microcarpus	Zang (1981a)	√
T. radicatus Natarajan	Wang & Liu (2002)	**
T. robustus (Beeli) R. Heim	Zang (1981a)	*, misidentification of *T. bulborhizus* or *T. eurrhizus*
T. schimperi (Pat.) R. Heim	Mao (2000)	*, without specimen support and the description does not coincide with that of Heim (1942)
T. spiniformis R. Heim	Mao (2000)	**
T. striatus	Zhang & Li (1988)	√
T. striatus f. *griseus* R. Heim	Mao (2000)	**
T. striatus f. *ochraceus* R. Heim	Mao (2000)	**
T. tylerianus	Bi et al. (1990)	√
Sinotermitomyces carnosus	Zang (1981b)	Synonym of *T. mammiformis*
S. cavus	Zang (1981b)	Synonym of *T. heimii*
S. griseus	Zang (1992)	Synonym of *T. mammiformis*
S. meipengianus M. Zang & D.Z. Zhang	Zang & Zhang (2004)	*, not *Termitomyces*
S. rugosiceps	Zang (1992)	Synonym of *T. mammiformis*
S. taiwanensis	Zang & Chen (1998)	Synonym of *T. clypeatus*

√ Recognized in China.

* Excluded Chinese records of misidentification or misapplied name.

** Unconfirmed Chinese records lacking support of specimen citation.

Termitomyces aurantiacus (R. Heim) R. Heim, Term. et Champ.: 56 (1977).

≡ *Termitomyces striatus* var. *aurantiacus* R. Heim, Denkschr. Schweiz. Naturf. Ges. 80: 23 (1952).

= *Termitomyces cylindricus* S.C. He, Acta Mycol. Sin. 4: 104 (1985) (see Tang et al. 2006b).

Pileus 3.0–10.0(–14.0) cm diam., at first conical to convex, convexo-applanate to up-curved when mature, with a small and bluntly pointed perforatorium (up to 5 mm high); surface reddish brown at centre and paler toward margin, smooth, glabrous; margin applanate, finely striate and splitting radially. Lamellae free, white at first, becoming pinkish; up to 8.0 mm wide, crowded, with lamellulae. Stipe 2.0–10.0 × 1.3–1.6 cm, central, cylindrical or sometimes slightly thickening; surface white, smooth, glabrous; solid fibrous, hard after drying, composed of longitudinally parallel hyphae, thin-walled, hyaline, 2.0–15.0 µm diam. Pseudorhiza up to 34 cm long, 0.3–2.5 cm thick, cylindrical, rarely tapering, slender, terminal with a soft white column between inner wall of termite nest and comb; surface white, longitudinally striate; solid, fibrous, of thin-walled and hyaline hyphae, 2.0–20 µm diam. Partial veil membranous, ephemeral. Context white, up to 8.0 mm thick under perforatorium, of inflated thin-walled and hyaline hyphae, 2.5–8.0 µm diam., inflating to 30 µm. Basidiospore deposit pinkish. Basidiospores 5.5–8.0 × 3.5–5.5 µm, ovoid to ellipsoid; subhyaline, thin-walled. Basidia 16.0–24 × 5.5–8.5 µm, clavate, with four sterigmata; thin-walled and subhyaline. Lamella edge heterogeneous. Cheilocystidia 15.0–31 × 9.0–20 µm, clavate to pyriform, thin-walled, hyaline. Pleurocystidia not found. Hymenophoral trama 60–80 µm wide, regular, of thin-walled and hyaline hyphae, 5.0–20 µm diam. Subhymenial layer 10.0 µm wide, of branched hyphae, 2.0–5.0 µm diam. Pileipellis a repent epicutis of narrow, radial hyphae, 1.5–4.5 µm diam.

Specimens examined: CHINA: Yunnan: Mengla, Monglun Town, the Xishuangbanna Tropical Botanic Garden, 2 Sept 1990, Z.-L. Yang 1274 (HKAS 23291); ibid, 8 Aug 2003, G.-R. Hu and T.-Z. Wei W03-19 (HMAS 84720); ibid, 14 Aug 2004, B.-H. Tang T04103 (HMAS 86671); Jingdong, Phenix Mountains, alt. 1260 m, 25 Aug 1991, Z.-L. Yang 1642 (HKAS 23955); Menghai, 15 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 240 (HMAS 76623). Guizhou: Xingyi, Baiwayao Town, alt. 1530 m, on nest of *Macrotermes orthognathus* Ping & Xu, 22 Aug 1983, S.-C. He 1062 (HKAS 14695, paratype of *T. cylindricus*), S.-C. He 1061 (HMAS 47851, paratype of *T. cylindricus*).

Termitomyces aurantiacus is mainly characterized by the medium-sized basidiomata, orange to reddish brown pileus, small pointed perforatorium and white pseudorhiza. The species is similar to *T. striatus* but differs in the bright pileus and hard stipe. The description of *T. cylindricus* (He 1985) closely resembles that of *T. aurantiacus* although it was considered by He (1985) to differ from other *Termitomyces* species by having a cylinder at the pseudorhiza base. Examination of two paratype collections of *T. cylindricus* (HMAS 47851

and HKAS 14695) confirms it to be a synonym of *T. aurantiacus* (Tang et al. 2006b).

Termitomyces aurantiacus is widely distributed in equatorial Africa (Heim 1977) and Southeastern Asia (Pegler & Vanhaecke 1994), and was first recorded by Yang & Shuai (1990) in China based on the material from Xishuangbanna of Yunnan Province. The species was also reported in Sichuan and Guizhou (Ying & Zang 1994, Yuan & Sun 1995, Hu et al. 2000, Mao et al. 1993), but only the distribution in the south of Yunnan was confirmed in this study. *Termitomyces aurantiacus* symbioses with *Pseudacanthotermes militaris* (Hagen) in Africa (Pegler & Vanhaecke 1994) and with *M. orthognathus* in China (He 1985).

Termitomyces bulborhizus T.Z. Wei, Y.J. Yao, B. Wang & Pegler, Mycol. Res. 108: 1458 (2004).

Pileus (5.0–)10.0–22 cm diam., at first convex, convexo-applanate or even upwardly curved when mature, with a protruding, roundly obtuse perforatorium; surface reddish brown to dark brown at centre, elsewhere pale brown to brown, and paling toward margin, smooth or rough; margin straight to upcurved, striate, often splitting radially. Lamellae free, up to 8.0 mm wide, white at first, and pinkish when mature; crowded, with lamellulae. Stipe 3.0–12.5 × 0.8–6.0 cm, central, cylindrical above, expanding to 2.8–9.0 cm diam. at ground level and usually abruptly forming a prominently bulbous base below ground, robust; surface white above and pale brown on the bulb; with concolorous persistent floccules; solid, fibrous, composed of longitudinally paralleled hyphae, thin-walled and hyaline, 2.0–18.0 μm diam. Pseudorhiza up to 80 cm long, narrowing to 0.6–1.6 cm immediately below the bulb or tapering towards the base at the termite comb; surface white to pale brown, very rough, with longitudinal grooves and cracks; solid and fibrous, of subparallel, thin-walled hyphae, hyaline, 2.0–25 μm diam. Partial veil membranous, fragile and ephemeral. Context up to 2.0 cm thick, white, fleshy, composed of thin-walled and hyaline hyphae, 2.5–8.0 μm diam. in normal, inflating to 35 μm diam. Basidiospore deposit pinkish. Basidiospores 6.0–9.0 × 4.0–6.0 μm, ovoid to ellipsoid, thin-walled, subhyaline. Basidia 17.5–27 × 5.5–9.0 μm, clavate, bearing four sterigmata; thin-walled and subhyaline. Lamella-edge heterogeneous. Cheilocystidia 19.0–60 × 12.0–34 μm, clavate to pyriform; thin-walled and hyaline. Pleurocystidia 19.0–78 × 10.0–32 μm, clavate to pyriform, occasionally turbinate; thin-walled and hyaline. Hymenophoral trama 50–80 μm wide, regular, of thin-walled, hyaline hyphae, 3.5–20 μm diam. Subhymenial layer 10.0–25 μm wide, of branched and repent hyphae, 2.0–6.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, 1.5–7.0 μm diam., contain yellowish pigment.

Specimens examined: CHINA: Sichuan: Miyi, purchased in local market, 9 Aug 2002, B. Wang 200222 (HMAS 84444, holotype; K(M) 109284, isotype), B. Wang 200223

(HMAS 76813); ibid, 18 Aug 2002, B. Wang 200244 (HMAS 84445); ibid, 27 Aug 2002, B. Wang 200245 (HMAS 84528); Chengdu, purchased in local market, 5 Aug 2003, B. Wang 20031 (HMAS 77080); ibid, 12 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH323 (HMAS 77078); Dechang, purchased in local market, 13 Aug 2003, H. Teng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH329-1 (HMAS 79890), H. Teng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH327 (HMAS 86679); ibid, 14 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-38 (HMAS 86682); ibid, 15 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-39 (HMAS 86684); ibid, on nest of *Macrotermes barneyi* Light, 16 Aug 2003, T.-Z. Wei and L. Jiao W03-44 (HMAS 86687), T.-Z. Wei and L. Jiao W03-45 (HMAS 86685), T.-Z. Wei and L. Jiao W03-46 (HMAS 88328), T.-Z. Wei and L. Jiao W03-47 (HMAS 84729), Q.-B. Wang and S.-Z. Fu W03-49 (HMAS 79895), S.-Z. Fu and Q.-B. Wang W03-51 (HMAS 85225); Huidong, 16 Jul 1982, X.-C. Li 82016 (HKAS 13279); Mingshan, Mengshan Village, alt. 1000 m, 24 Jul 1984, M.-S. Yuan 1003 (HKAS 15836); Yanyuan, 14 Aug 1992, P.-G. Liu and M.-S. Yuan 1370 (HKAS 25792). Yunnan: Kunming, purchased in local market, 1 Aug 2003, T.-Z. Wei and Q.-B. Wang W03-1 (HMAS 86683), T.-Z. Wei and Q.-B. Wang W03-2 (HMAS 77079), T.-Z. Wei and Q.-B. Wang W03-3 (HMAS 86678); ibid, 24 Jul 2004, B.-H. Tang T0404-2 (HMAS 86662); Chuxiong, purchased in local market, 26 Jul 2005, T.-Z. Wei and F.-Q. Yu Gm 884 (HMAS 130151); Mengla, Menglun Town, Xishuangbanna Tropical Botanic Garden, 8 Aug 2003, G.-R. Hu and T.-Z. Wei W03-22 (HMAS 84717), G.-R. Hu and T.-Z. Wei W03-25 (HMAS 79893); ibid, 3 Aug 2004, B.-H. Tang, T0472 (HMAS 96508); ibid, 5 Aug 2004, B.-H. Tang and A.-Y. Li T0483 (HMAS 86677); ibid, 6 Aug 2004, A.-Y. Li and B.-H. Tang T0486 (HMAS 86664), M. Li and B.-H. Tang, T0496 (HMAS 96672); Jingdong, on nest of termite, 17 Jul 1978, D.-G. Ji (HKAS 4413); Cangyuan, on nest of termite, 30 Aug 1980, M. Zang (HKAS 6750); ibid, 31 Aug 1981, M. Zang (HKAS 6753); ibid, 4 Sept 1980, sin coll. (HKAS 6900); Luquan, 18 Aug 1980, Z.-F. Zhang 1 (HKAS 9427); ibid, alt. 1920 m, on nest of *Odontotermes formosanus* Shiraki, 19 Aug 1980, Z.-F. Zhang 3 (HKAS 9429), Z.-F. Zhang 2 (HKAS 9428); Pinglang, alt. 1800 m, 30 Aug 1985, M. zang (HKAS 14665); Puer, purchased in local market, 31 Aug 1990, Z.-L. Yang 1237 (HKAS 22981); Nanjian, Wuliang Mountains, alt. 2200 m, 12 Aug 2001, M. Zang 13857 (HKAS 38560), M. Zang 13857a (HKAS 38561). Guangxi: Nanning, alt. 180 m, 2 Aug 1999, P.-Q. Sun 4200 (HKAS 34770). Guangdong: Shixing, 3 Sept 1984, T.-H. Li (HMIGD 7944); ibid, alt. 370 m, 17 Aug 1985, T.-H. Li (HMIGD 8996).

Termitomyces bulborhizus was based on specimens from Sichuan and Yunnan and further collections have since been made. The extensive specimen citation above indicates that it is very common in the south and southwest of China. It is mainly distinguished by the large basidioma, bulbous stipe base and floccose stipe surface. Chinese herbarium specimens were often misidentified as *T. aurantiacus*, *T. globulus* and *T. robustus*. *Termitomyces bulborhizus* is associated with *O. formosanus* and *M. barneyi*, two common termite species in the south of China (Huang et al. 2000).

Termitomyces clypeatus R. Heim, Bull. Jard. Bot. État. 21: 207 (1951).

= *Schulzeria goossensiae* Beeli, Bull. Soc. Roy. Bot. Belg. 60: 75 (1927), pro parte (see Heim 1951).

= *Sinotermitomyces taiwanensis* M. Zang & C.M. Chen, Fung. Sci. 13: 25 (1998) (see Wei et al. 2006).

Pileus 2.5–10.0(–14.0) cm diam., firstly conical, then becoming convexo-applanate with distinctly protrudent and sharply spiniform perforatorium which 5–12 mm high; surface greyish brown, brown, greyish black or dark brown at centre, and paling toward margin, smooth and glabrous, radially rimose; margin decurved to straight, striate and splitting radially. Lamellae free, 3.0–7.0 mm wide, white to pinkish, crowded, with lamellulae. Stipe 4.0–13.0 × 0.5–1.8 cm, central, cylindrical, occasionally slightly thickening at ground level, slender; surface white, smooth and glabrous, striate; solid, fibrous, consisting of longitudinally parallel hyphae, thin-walled and hyaline, 2.0–15.0 μm diam. Pseudorhiza up to 22 cm long, cylindrical, sometimes tapering; surface white to pale yellow or pale grey, longitudinally striate; solid and fibrous, of subparallel hyphae, thin-walled and hyaline, 2.5–25 μm diam. Partial veil absent. Context 3.0–5.0 mm thick under perforatorium, white, fleshy, of inflated thin-walled hyphae, 2.0–7.0 μm diam., inflating to 30 μm. Basidiospore deposit pinkish. Basidiospores 6.0–9.0 × 4.0–6.0 μm, ovoid to ellipsoid, thin-walled, subhyaline. Basidia 15.0–28 × 5.5–9.0 μm, clavate, thin-walled, subhyaline, with four sterigmata. Lamella edge heterogeneous. Cheilocystidia 16.0–50 × 8.0–25 μm, clavate to pyriform, thin-walled and hyaline. Pleurocystidia 15.0–74 × 9.0–25 μm, similar to cheilocystidia. Hymenophoral trama 40–90 μm wide, consisting of thin-walled and hyaline hyphae, 4.0–20 μm diam. Subhymenial layer 10.0–16.0 μm wide, of branched and repent hyphae, 2.0–5.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, 2.0–5.0 μm diam.

Specimens examined: CHINA: Yunnan: Kunming, purchased in local market, 1 Aug 2003, T.-Z. Wei and Q.-B. Wang W03-4 (HMAS 77077), T.-Z. Wei and Q.-B. Wang W03-5 (HMAS 84712); ibid, purchased in local market, 24 Jul 2004, B.-H. Tang T0402-1 (HMAS 86672), B.-H. Tang T0402-2 (HMAS 86673); ibid, purchased in local market, 25 Jul 2004, B.-H. Tang T0405 (HMAS 98968); ibid, purchased in local market, 27 Jul 2004, B.-H. Tang T0414-2 (HMAS 98961), B.-H. Tang T0421-1 (HMAS 98962), B.-H. Tang T0414-1 (HMAS 98970), B.-H. Tang T0414 (HMAS 98986), B.-H. Tang T0415 (HMAS 98963), B.-H. Tang T0420-1 (HMAS 98978), B.-H. Tang T0420-2 (HMAS 98971), B.-H. Tang T0418-1 (HMAS 96503), B.-H. Tang T0418-2 (HMAS 98947), B.-H. Tang T0419-1 (HMAS 98984), B.-H. Tang T0419-2 (HMAS 86674); ibid, 26 Aug 2002, F.-Q. Yu 961 (HKAS 41725); ibid, 24 Aug 1997, X.-H. Wang 6 (HKAS 31686); ibid, 30 Jul 1999, X.-H. Wang 730 (HKAS 34486); Lufeng, 26 Jul 2004, B.-H. Tang T0413 (HMAS 96506); Xundian, Xiaodianwei Village, 26 Jul 2004, B.-H. Tang and W.-Y. Yang T0407 (HMAS 86670); Jinghong, on termite nest, Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 6 (HMAS 63363); Mengla, on groud in forest edge, 3 Sept 1974, M. Zang (HKAS 1187); ibid, 14 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 174 (HMAS 63527); ibid, 11 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 119 (HMAS 76755); ibid, Menglun Town, purchased in the local market, 7 Aug 2004, M. Li and B.-H. Tang T0488 (HMAS 86666), M. Li and B.-H. Tang T0487 (HMAS 86669); ibid, Menglun Town, Xishuangbanna Tropical Botanic Garden, alt. 580 m, 4 Aug 1988, Z.-L. Yang 263 (HKAS 21788); ibid, 29 May 1990, J.-G. Shuai 9 (HKAS 23269); ibid, 5 Aug 2004, A.-Y. Li and B.-H. Tang T0475 (HMAS 96502); ibid, 8 Aug 2004, M. Li and B.-H. Tang T0492 (HMAS 98982), M. Li and B.-H. Tang T0499 (HMAS 96491); ibid, 10 Aug 2004, M. Li and B.-H. Tang

T04105 (HMAS 98989); ibid, 11 Aug 2004, A.-Y. Li T04111 (HMAS 98969); Pingbian, 22 Jun 1974, X.-J. Li (HKAS 856); Luchuan, on termite nest in woodland, 16 Sept 1973, H. Huang 16 (HKAS 16); Ruili, Dengga Mountains, alt. 750 m, 14 Jul 1977, X.-J. Li 158 (HKAS 2988); ibid, 28 Jul 1979, W.-K. Zheng 79072 (HKAS 4842); Lianghe, 1 Aug 1977, X.-J. Li 313 (HKAS 3137); Tengchong, purchased in market of Gudong Town, 17 Sept 1996, P.-G. Liu Liu-96-3 (HKAS 30291), P.-G. Liu Liu-96-4 (HKAS 30295); ibid, 5 Aug 1977, X.-J. Li 509 (HKAS 3345); ibid, alt. 2000 m, 12 Aug 1977, X.-J. Li 705 (HKAS 3594); ibid, 15 Sept 1996, P.-G. Liu Liu-96-6 (HKAS 30292); ibid, 18 Sept 1996, P.-G. Liu Liu-96-7 (HKAS 30290); Yuanmou, alt. 1900 m, 3 Aug 1976, M. Zang (HKAS 5509); Mangshi, on termite nest, 10 Aug 1980, M. Zang (HKAS 6542); Longling, on termite nest, 10 Aug 1981, M. Zang (HKAS 6543); Lijiang, Aug 1980, X.-J. Li 81-6 (HKAS 7495); Luquan, alt. 1900 m, 9 Jul 1980, Z.-F. Zhang 4 (HKAS 9430); Gejiu, on termite nest, Jul 1982, D.-G. Ji 82-6 (HKAS 9738); Pinglang, alt. 1800 m, 11 Aug 1985, M. Zang 10387 (HKAS 14664); Jinning, 2 Sept 1985, X.-Z. Guo 85009 (HKAS 14705); Binchuan, Jizu Mountains, 17 Aug 1985, G.-P. Xiao 484 (HKAS 17235); Simao, Red Flag Reservoir, alt. 1400 m, 11 Sept 1986, K.-K. Chen 104 (HKAS 17670); ibid, Caiyang River, alt. 1500 m, 3 Jul 2000, M. Zang 13555 (HKAS 36484); Jingdong, Big Bell Mountains, alt. 1500 m, 24 Aug 1991, P.-G. Liu (HKAS 23953); Qujing, 20 Aug 1991, Z.-L. Yang (HKAS 23959); Jiangcheng, Niuluo River, alt. 1100 m, 8 Aug 1991, G. Song 105 (HKAS 23973); ibid, Jingdong Village, alt. 1400 m, 6 Aug 1991, Z.-L. Yang 1401 (HKAS 23975); Menghai, alt. 1170 m, 12 Aug 1997, M. Zang 12286 (HKAS 30637); Yuxi, purchased in local market, 1 Jul 1998, X.-H. Wang 314 (HKAS 32971); ibid, purchased from roadside, 22 Jul 2005, T.-Z. Wei, X.-H. Wang, H.-D. Zheng and H. Knudsen Gm 859 (HMAS 133284); Wuding, purchased in local market, 12 Aug 1999, X.-H. Wang 747 (HKAS 34487), X.-H. Wang 744 (HKAS 34489); Songming, Arziying Township, 5 Aug 2005, T.-Z. Wei and F.-Q. Yu Gm 1070 (HMAS 133282), T.-Z. Wei and F.-Q. Yu Gm 1071 (HMAS 130153), T.-Z. Wei and F.-Q. Yu Gm 1072 (HMAS 130147); Nanhua, purchased from local market, 28 Jul 2005, T.-Z. Wei and F.-Q. Yu Gm 958 (HMAS 130150). Sichuan: Xichang, purchased in local market, 8 Aug 2002, B. Wang 200221 (HMAS 77065); ibid, 27 Aug 1983, M.-S. Yuan 210 (HKAS 11806); ibid, 12 Aug 1992, P.-G. Liu and M.-S. Yuan 1362 (HKAS 25787), P.-G. Liu and M.-S. Yuan 1366 (HKAS 25785); ibid, alt. 1800 m, 19 Sept 1999, M. Zang 13150 (HKAS 34455), M. Zang 13150a (HKAS 34456); Muli, 29 Aug 1983, K.-K. Chen and L.-S. Wang 83-883 (HKAS 12556); ibid, alt. 2500 m, 17 Aug 1992, P.-G. Liu and M.-S. Yuan 1390 (HKAS 25788); ibid, alt. 2300 m, 19 Aug 1992, P.-G. Liu and M.-S. Yuan 1476 (HKAS 25797); Huidong, Aug 1982, Science Committee of Huidong County (SCHC) 82024 (HKAS 13271), SCHC 82026 (HKAS 13272), SCHC 82015 (HKAS 13273); ibid, 29 Jul 1982, SCHC 82020 (HKAS 13274), SCHC 82021 (HKAS 13275); ibid, 22 Jul 1982, SCHC 82022 (HKAS 13276); ibid, 12 Jul 1982, X.-C. Li 82012 (HKAS 13277); ibid, 11 Jul 1982, X.-C. Li 82011 (HKAS 13278); ibid, 14 Jul 1982, X.-C. Li 82014 (HKAS 13280), X.-C. Li 82018 (HKAS 13281); ibid, 10 Jul 1982, X.-C. Li 82012 (HKAS 13282), X.-C. Li 82023 (HKAS 13283); Miyi, alt. 800 m, 24 Jul 1986, M.-S. Yuan 1147 (HKAS 18400); Meigu, alt. 1700 m, 27 Aug 1992, P.-G. Liu and M.-S. Yuan 1506 (HKAS 25789); Dechang, purchased in local market, 19 Jul 2002, B. Wang 20021 (HMAS 84514), B. Wang 20022 (HMAS 84520); ibid, 31 Jul 2002, B. Wang 200212 (HMAS 84522), B. Wang 200213 (HMAS 76901), B. Wang 200215 (HMAS 83594); Shuangliu, purchased in local market, 12 Aug 2002, B. Wang 200225 (HMAS 76906); Pujiang, 18 Aug 2002, B. Wang 200231 (HMAS 76905), B. Wang 200236 (HMAS 76907). Guangxi: Baise, alt. 200 m, 30 Aug 1999, M.-S. Yuan 4169 (HKAS 34795). Guangdong: Fengkai, alt. 380 m, 13 VI 1986, Z.-S. Bi and G. Li (HMIGD 10183).Hainan: Changjiang, Bawang Mountains Nature Reserve, alt. 1010–1050 m, on termite nest in mixed forest, 15 Aug 1988, J.-L.

Ying (HMIGD 14201); ibid, 5 Aug 1987, Q. Chen (HMIGD 12104); Ledong, Heaven Lake in Jianfengling Mountains, alt. 800 m, on nest of *Microtermes obesi* Holmgren, 22 Jul 1981, M.-Q. Gong 108 (HKAS 22362). Fujian: without details of locality, 17 Aug 1986, C.-Y. Chen (HKAS 17653). Taiwan: Taizhong, Dongshi Forestry Centre, 9 Aug 1995, C.-M. Chen 840369 (HKAS 30318); Nantou, Zhongxing Village, 13 Jul 1997, C.-M. Chen C1900 (HKAS 30524, holotype of *S. taiwanensis*).

Termitomyces clypeatus can be easily recognized by its sharp spiniform perforatorium, together with the slender habit and pale colored pseudorhiza. The species is similar to *T. aurantiacus* and *T. striatus* in the medium-sized basidiomata, pointed perforatorium and whitish pseudorhiza. However, the perforatorium of the latter two are obviously smaller and more obtuse (no more than 5 mm high) than that of *T. clypeatus* (5–12 mm high). Moreover, *T. clypeatus* lacks a partial veil, but *T. aurantiacus* and *T. striatus* have a membranous and fragile partial veil, although it is usually absent at maturity.

Termitomyces clypeatus was often misidentified as "*Termitomyces albuminosus* (Berk.) R. Heim" in Chinese records in the past (e.g. Zang 1981a, Ying & Zang 1994, Yuan & Sun 1995), whilst *S. taiwanensis* was confirmed as a synonym of *T. clypeatus* based on examination of the holotype (Wei et al. 2006).

Termitomyces clypeatus is widely distributed in Africa and Asia (Heim 1977, Pegler 1977, Pegler & Piearce 1980, Van der Westhuizen & Eicker 1990, Pegler & Vanhaecke 1994, Turnbull & Watling 1999) and a common species in the south and southwest of China (He 1985, Ying & Zang 1994, Bi et al. 1994, Yun & Sun 1995). The species is reported symbiotic with *Macrotermes falcifer* (Gerstacker) and *Odontotermes* sp. in Zambia, Africa (Piearce 1987) and growing on nests of *Odontotermes* species, e.g. *O. grandiceps* Holmgren, *O. malaccensis* Holmgren and *O. sarawakensis* Holmgren in Southeastern Asia (Bels & Pataragetvit 1982, Pegler & Vanhaecke 1994). In China, *T. clypeatus* was found on nests of *O. formosanus* (He 1985), *M. orthognathus*, *M. barneyi* (Huang 1993) and *Microtermes obesi* (this study).

Termitomyces entolomoides R. Heim, Denkschr. Schweiz. Naturf. Ges. 80: 23 (1952).

Pileus 3.5–4.0 cm diam., plano-convex to finally concave, with a small, sharply pointed perforatorium; surface black at centre, elsewhere greyish black, slightly paling towards the margin, smooth, glabrous, striate radially; margin straight or upcurved, splitting. Lamellae free, white to pinkish, 3.0–4.0 mm wide, densely crowded, with lamellulae. Stipe 4.5–5.0 cm long above ground, 0.5–0.7 cm thick close to apex, cylindrical, but swollen at ground level, solid, fibrous; surface pale grey, with small floccules. Pseudorhiza 4.0–5.5 cm long, 1.5–1.7 cm thick close to ground level, tapering, with a white, cylindrical base connected with the termite nest; surface grey, with longitudinal grooves. Partial veil absent. Context white, fleshy, thin, comprised of repent, thin-walled hyphae, 3.0–7.0

μm diam, inflating to 35 μm diam. Spore deposit pink. Basidiospores 5.5–7.0 × 3.5–4.5 μm, ovoid to ellipsoid, subhyaline, thin-walled. Basidia 17.0–22 × 6.0–7.0 μm, clavate, bearing four sterigmata, subhyaline. Hymenophoral trama regular, 60–80 μm wide, with hyaline hyphae, 5.0–20 μm diam. Subhymenial layer 8.0–10.0 μm wide, consisting of repent hyphae, 2.0–5.0 μm diam. Lamella-edge heterogeneous. Cheilocystidia clavate to pyriform, 28–60 × 13.0–31 μm, thin-walled, hyaline. Pleurocystidia rare, clavate to pyriform, 23–41 × 9.0–26 μm, thin-walled, hyaline. Pileipellis a repent epicutis of narrow, radial hyphae with yellowish vacuolar pigment, 3.0–5.0 μm diam.

Specimen examined: CHINA: Guangdong: Huidong, Gutian, 400 m alt., on ground in broadleaf woodland, 11 Jul 1987, G.-Y. Zheng (HMIGD11367).

Termitomyces entolomoides is a taxon with small to medium-sized basidiomata (Pegler & Vanhaecke 1994, Wei et al. 2003). It was described by Heim (1952) based on African material and later reported from Southeastern Asia (Pegler & Vanhaecke 1994, Turnbull & Watling 1999). *Termitomyces entolomoides* was also reported from China recently (Wei et al. 2003), after a comparison of the Chinese collection with specimens of the species studied by Pegler & Vanhaecke (1994), and several other similar species, e.g. *T. aurantiacus*, *T. sagittiformis* (Kalchbr. & Cooke) D. A. Reid and *T. striatus*. The Chinese collection strongly resembles the three collections of *T. entolomoides* from Malaysia and Singapore cited by Pegler & Vanhaecke (1994), i.e. K(M) 16520, K(M) 94651 and K(M) 109534, but attempts with DNA isolation and amplification from these four collections proved unsuccessful owing to their poor condition. In a phylogenetic analysis of *Termitomyces*, Frøslev et al. (2003) found two named collections of *T. entolomoides* were molecularly very divergent: one (tgf10, from E. Turnbull & R. Watling) was molecularly close to *T. clypeatus* and the other (tgf103, from B. Buyck) to *T. microcarpus*. However, no description of these two collections is available and the present authors have been unable to obtain the material for comparison with the Chinese collection. The associated termite of *T. entolomoides* is *Macrotermes gilvus* (Hagen) in Malaysia (Pegler & Vanhaecke 1994).

Termitomyces eurrhizus (Berk.) R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 140 (1942).

≡ *Agaricus eurrhizus* Berk., Lond. Journ. Bot. 6: 483 (1847).

≡ *Armillaria eurrhiza* (Berk.) Sacc. [as "*eurhiza*"], Syll. Fung. 5: 85 (1887).

≡ *Collybia eurrhiza* (Berk.) Höhn. [as "*eurhiza*"], Sitzungsber. K. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 117: 992 (1908).

≡ *Rajapa eurrhiza* (Berk.) Singer [as "*eurhiza*"], Lloydia 8: 143 (1945).

= *Collybia albuminosa* sensu Petch, Ann. Roy. Bot. Gard., Peradeniya 5: 268 (1912), non *Agaricus albuminosus* Berk. (see Pegler 1994).

= *Termitomyces cartilagineus* (Berk.) R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 116 (1942) (see Pegler 1977).

= *Termitomyces poonensis* Sathe & S.D. Deshp., Maharashtra Assoc. Cult. Sci., Monograph 1: 36 (1981) ["1980"] (see Tang et al. 2006a).

= *Termitomyces quilonensis* Sathe & J.T. Daniel [as "*quilonesis*"], Maharashtra Assoc. Cult. Sci., Monograph 1: 103 (1981) ["1980"] (see Tang et al. 2006a).

= *Termitomyces albiceps* S.C. He, Acta Mycol. Sin. 4: 106 (1985) (see Tang et al. 2006b).

= *Termitomyces macrocarpus* Z.F. Zhang & X.Y. Ruan, Acta Mycol. Sin. 5: 10 (1986) (see Tang et al. 2006b).

= *Termitomyces albuminosus* sensu auct. Sin.

Pileus 7.0–20 cm diam., convex at first, applanate to concave when mature with round or bluntly pointed perforatorium; surface brown, reddish brown, dark brown to almost black at centre, white, pale yellow, pale grey, yellowish brown to dark brown elsewhere, usually paling toward margin, smooth and glabrous, rimose and striate radially; margin straight when mature, often splitting. Lamellae free, white to pinkish, 2.0–9.0 mm wide, crowded, with lamellulae. Stipe 3.0–15.0 × 0.5–2.8 cm, central, cylindrical and more or less thickening at ground level; surface white, and turning into pale yellowish brown close to ground level, smooth or with a few ephemeral remnants of partial veil; solid, fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, 2.0–20 μm diam. Pseudorhiza 35 cm or more long, tapering; surface dark brown just under ground level, and black below, cartilaginous, striate and cracked longitudinally; solid, fibrous, of parallel to subparallel hyphae, thin-walled and hyaline, 2.5–35 μm diam. Partial veil present between pileus edge and stipe surface, fragile, absent when mature or occasionally forming small squamules on stipe surface. Context 2.0–10.0 mm thick, white, fleshy, of inflated hyphae, thin-walled and hyaline, 2.5–8.0 μm diam. in normal, and inflating to 35 μm. Basidiospore deposit pinkish. Basidiospores 6.0–9.0(–12.5) × 4.0–6.0(–7.5) μm, ovoid to ellipsoid; thin-walled, subhyaline. Basidia 15.0–29 × 5.0–9.0 μm, clavate, bearing four sterigmata; thin-walled, subhyaline. Lamella edge heterogeneous, crowded with numerous cheilocystidia and few basidia. Cheilocystidia 13.0–55 × 9.0–33 μm, clavate to pyriform; thin-walled, hyaline. Pleurocystidia 18.0–69 × 10.0–35 μm, clavate to pyriform, or fusiform occasionally; thin-walled, hyaline. Hymenophoral trama 50–90 μm wide, regular, of thin-walled and hyaline hyphae, 4.0–20 μm diam. Subhymenial layer 8.0–18.0 μm wide, of repent branched hyphae, 2.0–6.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae with yellowish pigment, 2.0–4.5 μm diam.

Specimens examined: CHINA. Yunnan: Kunming, purchased in local market, 21 Sept 1997, sin coll. 97-118 (HKAS 31891); ibid, Oct 2000, X.-H. Wang 1187 (HKAS 36868); ibid, purchased in local market, 24 Jul 2004, B.-H. Tang T0403 (HMAS 98972), B.-H. Tang T0404-1 (HMAS 98966), B.-H. Tang T0401 (HMAS 96673); Qiubei, 21 Jul 1977, M. Zang (HKAS 3461); Luquan, alt. 1900 m, on nest of *O. formosanus*, 9 Jul 1980, Z.-F. Zhang 5 (HKAS 9431); Xundian, Xiaodianwei Village, purchased from local villager, 26 Jul 2004, Y.-B. Wu T0408 (HMAS 98973), B.-H. Tang T0412 (HMAS 86667); Puer, 12 Sept 1986, K.-K. Chen 74 (N) (HKAS 18186); Mengla, Menglun Town, purchased in the

local market, 8 Aug 2004, M. Li T0490 (HMAS 86663); ibid, 5 Aug 2004, B.-H. Tang and A.-Y. Li T0484 (HMAS 96676); ibid, Menglun Town, Xishuangbanna Tropical Botanic Garden, 8 Aug 2003, G.-R. Hu and T.-Z. Wei W03-27 (HMAS 88326), G.-R. Hu and T.-Z. Wei W03-21 (HMAS 84723); ibid, 10 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 68 (HMAS 76622); ibid, 4 Aug 1988, Z.-L. Yang 262 (HKAS 21785); ibid, alt. 580 m,9 Aug 1988, Z.-L. Yang 342 (HKAS 21786); ibid, 2 Aug 2004, M. Li and B.-H. Tang T0457 (HMAS 98977), M. Li T0453 (HMAS 96507), A.-Y. Li and B.-H. Tang T0470 (HMAS 96516), A.-Y. Li and B.-H. Tang T04108 (HMAS 96677); ibid, 5 Aug 2004, B.-H. Tang and A.-Y. Li T0478 (HMAS 96509); ibid, 7 Aug 2004, M. Li and B.-H. Tang T0489 (HMAS 96496); Chuxiong, Nanhua, purchased in the local market, 17 Aug 2004, J.-Y. Chen, T04117 (HMAS 96510); Jinggu, Mengban, 21 Aug 1991, Z.-L. Yang 1620 (HKAS 23961); Jingdong, Phenix Mountains, alt. 1268 m, 25 Aug 1991, Z.-L. Yang 1641 (HKAS 23962), G. Song 291 (HKAS 23969); ibid, 29 Jul 1998, X.-H. Wang 488 (HKAS 32897); Simao, purchased in local market, 10 Aug 2003, T.-Z. Wei and Q.-B. Wang W03-30 (HMAS 85229); ibid, Xima River, alt. 1450 m, 2 Aug 1991, P.-G. Liu 810 (HKAS 24635); ibid, Caiyang River Nature Reserve, alt. 1680 m, 23 Jun 2000, M. Zang 13601 (HKAS 36001); ibid, alt. 1500 m, 16 Jul 2000, M. Zang 13334 (HKAS 36196); ibid, alt. 1680 m, 3 Jul 2000, M. Zang 13502 (HKAS 36497); Baoshan, Golden Cock Town, 21 Aug 1992, Z.-L. Yang (HKAS 25497); ibid, 30 Sept 1998, Z.-L. Yang 2571 (HKAS 32111); Yuxi, purchased in local market, 1 Jul 1998, X.-H. Wang 315 (HKAS 32969), X.-H. Wang 316 (HKAS 32972). Sichuan: Chengdu, purchased in local market, 30 Aug 2002, B. Wang 200252 (HMAS 84529); ibid, 12 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH326 (HMAS 79896); Huidong, Aug 1982, SCHC 82025 (HKAS 13269), SCHC 82017 (HKAS 13270); Pujiang, 5 Sept 1986, M.-S. Yuan 1301 (HKAS 18350); ibid, purchased in local market, 18 Aug 2002, B. Wang 200227 (HMAS 84518), B. Wang 200228 (HMAS 84516), B. Wang 200229 (HMAS 76898), B. Wang 200230 (HMAS 76909), B. Wang 200233 (HMAS 77064), B. Wang 200234 (HMAS 83595), B. Wang 200235 (HMAS 76913), B. Wang 200237 (HMAS 76899), B. Wang 200238 (HMAS 84517), B. Wang 200241 (HMAS 76895), B. Wang 200243 (HMAS 77060), B. Wang 200242 (HMAS 84530), B. Wang 200253 (HMAS 84527); ibid, 20 Aug 2002, B. Wang 200239 (HMAS 77063); Dechang, purchased in local market, 19 Jul 2002, B. Wang 20023 (HMAS 84526), B. Wang 20024 (HMAS 76912); ibid, 31 Jul 2002, B. Wang 200211 (HMAS 76902); ibid, Badong Town, 16 Aug 2003, T.-Z. Wei and L. Jiao W03-50 (HMAS 79891); ibid, 15 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-37 (HMAS 84715), H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-41 (HMAS 84722); ibid, 14 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-40 (HMAS 86686); ibid, 13 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH328 (HMAS 84726), H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH329 (HMAS 85226); ibid, 12 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao DH326 (HMAS 79897); Miyi, purchased in local market, 7 Aug 2002, B. Wang 200216 (HMAS 76908); Shuangliu, purchased in local market, 12 Aug 2002, B. Wang 200224 (HMAS 76903), B. Wang 200226 (HMAS 84521); Jianyang, purchased in local market, 30 Aug 2002, B. Wang 200246 (HMAS 76896), B. Wang 200247 (HMAS 76904), B. Wang 200248 (HMAS 84519), B. Wang 200249 (HMAS 84524), B. Wang 200250 (HMAS 76910), B. Wang 200251 (HMAS 77061). GUIZHOU: Xingyi, Baiwayao, alt. 1530 m, on nest of *O. formosanus*, 26 Aug 1983, S.-C. He 469 (HKAS 14660, paratype of *T. albiceps*); ibid, on nest of *O. formosanus*, 22 Aug 1983, S.-C. He 1056 (HMAS 47850, paratype of *T. albiceps*). XIZANG: Muotuo, 17 Jul 1983, Y.-G. Su 4850 (HKAS 15987), Y.-G. Su 4850B (HKAS 16184); ibid, on termite nest, 24 Jul 1983, X.-L. Mao 1139 (HMAS 50901); ibid, 11 Jul 1983, X.-L. Mao 1195 (HMAS 51474). Guangdong: Guangzhou, in mixed woodland, 30 May 1983, T.-H. Li (HMIGD 7184); ibid, Guangzhou Botanic Garden, 5

Jul 1985, G.-Y. Zheng (HMIGD 6569); Chaozhou, Phenix Mountains, alt. 400–450 m, solitarily grow on termite nest, 13 May 1986, G.-Y. Zheng (HMIGD 10437); ibid, 18 May 1986, G.-Y. Zheng (HMIGD 10491); Taishan, Shangchuan Island, 21 Jun 1987, Z.-S. Bi and T.-H. Li (HMIGD 11628); Yangchun, Guigang Town, alt. 600 m, on termite nest, 17 Jun 1987, Z.-S. Bi (HMIGD 11619). Hainan: Ledong, Jianfeng Mountains, alt. 680–730 m, on termite nest in broad leaved forest, 17 Aug 1988, H.-Q. Chen (HMIGD 15478).

Termitomyces eurrhizus is one of the species in the genus typified by large basidiomata in the genus. Its pileus often exceeds 12 cm in diameter. The species can be recognized mainly by the cartilaginous blackish pseudorhiza (Heim 1942, Pegler 1977, 1986, Pegler & Vanhaecke 1994). The pileal surface of *T. eurrhizus* is diversified from almost white to dark brown with basidiospores up to 12.5 × 7.5 μm. Some collections of *T. eurrhizus* were misidentified as *T. fuliginosus* or *T. robustus* previously in the Chinese herbaria and re-determined here based on black pseudorhiza.

Pegler & Rayner (1969) reduced *T. cartilagineus* to a synonym of *T. eurrhizus* and that is confirmed by this study based on examination of a collection from South Africa (PREM 43147). There are two other new species reported from China, namely *T. albiceps* and *T. macrocarpus*, also having a dark pseudorhiza by which they have been related to *T. eurrhizus*, and subsequently Tang et al. (2006b) confirmed the two taxa as conspecific with *T. eurrhizus*. According to Tang et al. (2006a), two additional new species from India, *T. poonensis* and *T. quilonensis*, are further synonyms of *T. eurrhizus*.

Termitomyces eurrhizus is one of the most common species of the genus with the widest distribution (Heim 1977, Pegler 1977, Pegler & Vanhaecke 1994) and has been found in many localities in the south of China (Teng 1963, Bi et al. 1994, 1997, Yuan & Sun 1995, Mao 2000). The termites associated include *Ancistrotermes latinotus* (Holmgren), *Pseudacanthotermes spiniger* (Sjöstedt) and *Odontotermes* sp. in Zambia (Piearce 1987) and with *M. gilvus* and *O. badius* Haviland in the south and southeast of Asia (Pegler & Vanhaecke 1994). In China, the species was found on nests of *Odontotermes* spp. and *Macrotermes* spp. (He 1985, Mao 1993, Yuan & Sun 1995).

Termitomyces globulus R. Heim & Gooss.–Font., Bull. Jard. Bot. État. 21: 216 (1951).

Pileus 12.0–21 cm diam., subglobose to applanate, perforatorium absent; surface reddish brown at centre, elsewhere yellowish brown, and paler toward margin, smooth, glabrous, often with radial fine striae, and cracking radially on expansion or drying; margin usually incurved or decurved when mature, splitting radially. Lamellae free, white to pinkish, 3.0–6.0 cm wide, crowded, with lamellulae. Stipe 4.0–7.0 × 1.2–3.0 cm, cylindrical, slightly widen at ground level; surface white, smooth, glabrous; solid, fibrous, of parallel hyphae, thin-walled and hyaline, 2.0–18.0 μm diam. Partial veil not found.

Pseudorhiza up to 35 cm or more long, tapering and often twisting; surface reddish brown to tawny brown, with longitudinal striae; solid and fibrous, consisting of subparallel hyphae, thin-walled and hyaline, 2.5–30 µm diam. Context 5.0–10.0 mm thick at perforatorium, white, fleshy, consisting of thin-walled, inflated hyphae, 2.5–7.5 µm diam., inflating to 35 µm. Spore deposit pinkish. Basidiospores 6.0–9.0 × 4.0–6.0 µm, ovoid to ellipsoid, thin-walled, subhyaline. Basidia 17.5–29 × 6.0–9.0 µm, clavate, bearing four sterigmata; thin-walled, subhyaline. Hymenophoral trama regular, consisting of with thin-walled, hyaline hyphae, 4.0–20 µm diam. Subhymenial layer 15.0 µm wide, of repent and branched hyphae 2.0–5.0 µm diam. Lamella-edge heterogeneous. Cheilocystidia 20–51 × 16.0–24 µm, clavate to pyriform, thin-walled, hyaline. Pleurocystidia 35–71 × 17.0–28 µm, clavate to pyriform, occasionally septate at apex, thin-walled, hyaline. Pileipellis a repent epicutis of narrow, radial hyphae, 2.0–7.5 µm diam., containing yellowish brown vacuolar pigments.

Specimens examined: CHINA: Sichuan: Miyi, 7 Aug 2002, B. Wang 200217 (HMAS 77062), B. Wang 200218 (HMAS 84515), B. Wang 200219 (HMAS 76897), B. Wang 200220 (HMAS 76911). Yunnan: Kunming, purchased in local market, 14 Aug 2004, B.-H. Tang T04112 (HMAS 98965), B.-H. Tang T04115 (HMAS 99991); ibid, 27 Jul 2004, B.-H. Tang T0414-3 (HMAS 96497), B.-H. Tang T0416 (HMAS 98976).

Termitomyces globulus is characterized by its large basidioma, subglobose and non-umbonate pileus and dark pseudorhiza. The species is similar to *T. eurrhizus* and *T. robustus*, differing, however, by the lack of a perforatorium, which is conspicuous in the other two species. Furthermore, the pileus margin of *T. eurrhizus* and *T. robustus* are straight or even upwardly curved when mature, but *T. globulus* still remains decurved to incurved. Furthermore, *T. globulus* has a brown to reddish brown pseudorhiza, differing from the black one of *T. eurrhizus*.

Termitomyces globulus was reported in central Africa (Heim 1951, 1977, Otieno 1966, Pegler 1977, Turnbull & Watling 1999) and Southeast Asia (Pegler & Vanhaecke 1994), and Bels & Pataragetvit (1982) reported that the species symbioses with *Macrotermes* spp.

Termitomyces heimii Natarajan, Mycologia 71: 853 (1979).

≡ *Termitomyces albuminosus* sensu R. Heim, Termit. et Champ.: 100 (1977), non *Agaricus albuminosus* Berk.

= *Termitomyces longiradicatus* Sathe & J.T. Daniel [as "*longiradicata*"], Maharashtra Assoc. Cult. Sci., Monograph 1: 102 (1981) ["1980"] (see Tang et al. 2006a).

= *Sinotermitomyces cavus* M. Zang, Mycotaxon 13: 172 (1981) (see Wei et al. 2006).

Pileus 1.5–9.0 cm diam., subglobose to campanulate at first, convexo-applanate with round perforatorium when mature; surface pale grey to dark brown at centre, white to cream elsewhere, completely covered by a partial veil when young, with persistent pale brown velar squamules when mature, and

perforatorium surface rough and occasionally covered by a discoid remains of partial veil; margin incurved when young and then becoming straight, often striate and splitting radially. Lamellae free, up to 8.0 mm wide, white to cream; crowded, with lamellulae. Stipe 2.0–8.0 × 1.0–2.2 cm, central, close to conical above annulus, and cylindrical below; surface annulate, white above annulus, and cream below with pale brown velar squamules formed by remains of partial veil; solid to soft, fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, usually 2.0–7.5 μm diam., few up to 18.0 μm. Pseudorhiza 29 cm or longer, cylindrical, slender, with a disk in contact with comb of termite; surface cream, leathery; hollow. Partial veil thin and tough, eventually forming a persistent double annulus and squamules on pileus and stipe surfaces; membranous, consisting of narrow hyphae, which are compactly parallel-arranged and perpendicular to surfaces of pileus and stipe, 1.5–3.0 μm diam. Context up to 10.0 mm thick, white, fleshy, of inflated thin-walled hyphae, hyaline, 3.5–8.0 μm. diam., inflating to 30 μm. Basidiospore deposit cream. Basidiospores 6.0–9.5 × 4.0–6.0 μm, ovoid to ellipsoid; thin-walled and subhyaline. Basidia 18.0–29 × 6.0–8.5 μm, clavate, bear four sterigmata; thin-walled, subhyaline. Lamella edge heterogeneous. Cheilocystidia 21–35 × 14.0–20 μm, clavate to pyriform; thin-walled and hyaline. Pleurocystidia 20–34 × 11.0–18.0 μm, similar to cheilocystidia, rare. Hymenophoral trama up to 100 μm wide, regular; of thin-walled and hyaline hyphae, 5.0–20 μm diam. Subhymenial layer about 10.0 μm wide, of narrow repent hyphae, thin-walled, 2.0–4.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, 2.0–4.5 μm diam.

Specimens examined: CHINA: Yunnan: Jinghong, purchased in local market, 3 Aug 2003, T.-Z. Wei and Q.-B. Wang W03-6 (HMAS 77076); Mengla, Menglun Town, purchased in local market, 5 Aug 2003, M. Li, T.-Z. Wei and Q.-B. Wang W03-8 (HMAS 77075); ibid, 12 Nov. 1989, Z.-L. Yang 984 (HKAS 22118); ibid, 16 Jul 1990, J.-G. Shuai 1 (HKAS 22668); ibid, 30 Jul 2004, B.-H. Tang T0422 (HMAS 98988); Luxi, Santai Mountains, alt. 1370 m, 1 Jul 1977, X.-J. Li 36 (HKAS 2866); Tengchong, alt. 2100, on nest of termite, 8 Aug 1980, X.-J. Li 11 (HKAS 6533, holotype of *S. cavus*); ibid, 17 Jul 1979, S.-X. Ma 1 (HKAS 4613), S.-X. Ma 2 (HKAS 4613); Ruili, 13 Aug 1980, X.-J. Li 22 (HKAS 6568); Longling, 2 Jul 1977, X.-J. Li 73 (HKAS 3664); Mangshi, 10 Aug 1980, M. Zang (HKAS 6545); Simao, on nest of termite, alt. 1500 m, 14 Jun 2000, M. Zang 13287 (HKAS 36153); ibid, alt. 1400 m, 17 Jun 2000, M. Zang 13372 (HKAS 36154); Jinggu, 10 Jul 1985, K.-Y. Guan 1 (HKAS 14626). XIZANG: Muotuo, 25 Sept 1983, Y.-G. Su 1343 (HKAS 16253).

Termitomyces heimii is a medium-sized species, and chiefly differs from other *Termitomyces* species by the velar squamules on the pileus and stipe surfaces, a double-ringed annulus and a hollow pseudorhiza. Wei et al. (2006) proved the type species of *Sinotermitomyces*, *S. cavus*, to be a synonym of *T. heimii*. Further, *T. longiradicatus*, a new species from Southwest India, is also conspecific with *T. heimii* (Tang et al., 2006a).

Termitomyces heimii was proposed by Natarajan (1979) based on of a collection from India which was misidentified as "*T. albuminosus* (Berk.) R. Heim" by Heim (1977). The species is widely distributed in south and south-east Asia (Natarajan 1979, Pegler & Vanhaecke 1994, Turnbull & Watling 1999), but it has not been found outside Asia. It was reported from Yunnan and Fujian, but was subsequently shown to be distributed only in South Yunnan and South-east Xizang in China (this study). *Termitomyces heimii* grows on the nests of a few *Odontotermes* species, including *O. grandiceps* in Malaysia (Pegler & Vanhaecke 1994) and *Odontotermes* spp. in China (Zang 1981b).

Termitomyces mammiformis R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 147 (1942).

= *Sinotermitomyces carnosus* M. Zang, Mycotaxon 13: 172 (1981) (see Wei et al. 2006).

= *Sinotermitomyces griseus* M. Zang, Mycotaxon 44: 22 (1992) (see Wei et al. 2006).

= *Sinotermitomyces rugosiceps* M. Zang, Mycotaxon 44: 23 (1992) (see Wei et al. 2006).

Pileus 3.5–8.5 cm cm in diam., at first subglobose or campanulate, and then becoming applanate with a mammiform, scrobiculate perforatorium; surface pale brown to dark brown at centre, and white to cream elsewhere, covered by a persistent cream partial veil when young, and attached by some firm pale grey to pale brown velar squamules when mature; margin incurved to straight, striate radially, and often splitting when mature. Lamellae free, 3.0–5.0 mm wide, surface white to pinkish, crowded, with lamellulae. Stipe 2.0–10.0 or more long, and 0.6–1.9 cm diam. at annulus, central, close to conical above annulus, and cylindrical below or occasionally slightly enlarged at ground level; surface white and glabrous above annulus, and cream-colored and with pale brown squamules below; solid, fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, 2.0–7.0 μm diam. Pseudorhiza up to 40 cm long, cylindrical, with a basal disk connecting to the comb of symbiotic termite; surface cream, leathery; hollow. Partial veil covering whole surface of pileus and stipe at first, and breaking into firm squamules and forming persistent double annulus on the upper surface; composed of narrow hyphae which are compactly parallel-arranged and perpendicular to the surfaces of pileus and stipe, 2.0–3.0 μm diam. Context white, fresh; solid to soft, of inflated hyphae, thin-walled and hyaline, 2.0–8.0 μm diam., and inflating to 28 μm. Basidiospore deposit cream. Basidiospores 6.0–8.5 × 4.0–6.0 μm, ovoid to ellipsoid, subhyaline and thin-walled. Basidia 16.0–28 × 6.0–9.0 μm, subhyaline and thin-walled, clavate, bearing 4 sterigmata. Lamella edge heterogeneous. Cheilocystidia 16.0–43 × 9.0–25 μm, clavate to pyriform, hyaline and thin-walled. Pleurocystidia 15.0–36 × 9.0–20 μm, similar to cheilocystidia, rare. Hymenophoral trama regular, 50–100 μm wide, of hyaline, thin-walled tube-like hyphae, 4.0–20 μm diam. Subhymenial layer up to 12.0 μm wide, of branched and repent hyphae, 2.0–5.0

μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, 3.0–5.0 μm diam.

Specimens examined: CHINA: Yunnan: Xishuanbanna, 12 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun (HMAS 76625); Mengla, 10 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 58 (HMAS 76553); Mengla, Menglun Town, purchased in local market, B.-H. Tang T0423 (HMAS 98987); Tengchong, on nest of termite, 30 Aug 1980, M. Zang (HKAS 6752, holotype of *S. carnosus*); Longchuan, 24 May 1992, M. Zang (HKAS 25361); Dehong, alt. 800 m, 9 May 1992, M. Zang 11907 (HKAS 25359); ibid, alt. 820 m, 19 May 1992, M. Zang 11908 (HKAS 25360); XIZANG: Muotuo, alt. 1250 m, on nest of termite, 3 Sept 1982, Y.-G. Su 1080 (HKAS 15983).

Termitomyces mammiformis is uniquely distinguished within the genus by a mammiform and scrobiculate perforatorium. The species may be closely allied to *T. heimii*, which differs by an obtusely rounded perforatorium. The perforatorium of *T. robustus* is also mammiform, but it lacks an annulate and scrobiculate stipe. Wei et al. (2006) investigated material of *S. carnosus*, *S. griseus* and *S. rugosiceps* and concluded all are synonymous with *T. mammiformis*. Further, Pegler (1977) observed the holotype collection of *T. rabuorii* Otieno, which also had a scrobiculate perforatorium, and considered it to be *T. mammiformis*. However, according to descriptions of Otieno (1966) and Pegler (1977), the pseudorhiza surface of *T. rabuorii* is dark brown and distinctly differs from that of *T. mammiformis*. Therefore, the identity of *T. rabuorii* requires further clarification.

Termitomyces mammiformis was published by Heim (1942) based upon material from the Republic of Guinea (formerly French Guinea). Similarly to *T. heimii*, *T. mammiformis* is only distributed in the South Yunnan and Southeast Xizang in China. The original record of a collection from Malaysia (KM 16528, cited by Pegler & Vanhaecke (1994)) shows that the species symbioses with *Odontotermes* spp.

Termitomyces microcarpus (Berk. & Broome) R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 128 (1942).

≡ *Agaricus microcarpus* Berk. & Broome, Journ. Linn. Soc., Bot. 11: 537 (1871).
≡ *Entoloma microcarpum* (Berk. & Broome) Sacc., Syll. Fung. 5: 687 (1887).
≡ *Mycena microcarpa* (Berk. & Broome) Pat., Bull. Soc. Mycol. Fr. 29: 210 (1913).
≡ *Gymnopus microcarpus* (Berk. & Broome) Overeem, in Heyne, Nutt. P. Ned.-Ind., ed. 2, 1: 76 (1927).
≡ *Podabrella microcarpa* (Berk. & Broome) Singer, Lloydia 8: 144 (1945).
= *Hiatula tonkinensis* Pat., J. Bot. (Morot) 5: 308 (1891) (see Yang 2000).
= *Termitomyces narobiensis* Otieno, Proc. E. Afr. Acad. 2: 110 (1966) ["1964"] (see Pegler 1977).
= *Termitomyces badius* Otieno, Sydowia 22: 161 (1969) ["1968"] (see Pegler 1977).
? = *Termitomyces indicus* Natarajan, Kavaka 3: 63 (1976 ["1975"]).

Pileus 1.0–3.2(–4.2) cm, at first conical becoming applanate when mature, with small and obtusely pointed perforatorium; surface white, pale grey, dark

grey or greyish brown at centre, white to pale grey elsewhere, paling toward margin, smooth and glabrous, radially striate; margin straight, often splitting when mature. Lamellae free, 2.0–5.0 mm wide; white at first, becoming pinkish when mature; crowded, with lamellulae. Stipe 1.5–6.0(–8.0) × 0.1–0.4(–0.6) cm, central, cylindrical, stipe base abrupt or forming a root-like terminal of 1.0–4.0 cm long under ground level, in contact with debris of comb brought to ground level, surface white, smooth and glabrous, longitudinally striate; solid and fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, 2.5–7.5(–10.0) μm diam. Partial veil absent. Context narrow, white and fleshy, of inflated hyphae, thin-walled and hyaline, normal hyphae 3.0–8.0 μm diam., inflating to 30 μm. Basidiospore deposit pinkish. Basidiospores 5.5–8.0 × 3.5–5.5 μm, ovoid to ellipsoid; thin-walled and subhyaline. Basidia 16.0–26 × 6.0–9.0 μm, clavate, bearing four sterigmata; thin-walled, subhyaline. Lamella edge heterogeneous. Cheilocystidia 15.0–48 × 9.0–20 μm, clavate to pyriform; thin-walled and hyaline. Pleurocystidia 23–44 × 9.0–26 μm, similar to cheilocystidia, rare. Hymenophoral trama regular, 50–60 μm wide, of thin-walled and hyaline hyphae, 4.0–20 μm diam. Subhymenial layer up to 15.0 μm wide, of branched and repent hyphae, thin-walled, 2.0–5.0 μm diam. Pileipellis a repent epicutis of narrow, repent, radial hyphae, thin-walled, 2.0–5.0 μm diam.

Specimens examined. CHINA. Yunnan: Lianghe Pasture, 31 Jul 1977, X.-J. Li 304 (HKAS 3475); Tengchong, 8 Aug 1980, M. Zang (HKAS 6505), M. Zang (HKAS 6517); Mengla, 10 Aug 1999, S.-X. Sun, H.-A. Wen and X.-L. Mao 63 (HMAS 63358); ibid, 9 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 45 (HMAS 78413); ibid, Menglun Town, at roadside, alt. 580 m, 4 Aug 1988, Z.-L. Yang 266 (HKAS 21787); ibid, 2 Sept 1990, Z.-L. Yang 1248 (HKAS 23285); ibid, 15 Aug 1994, M. Zang 12310 (HKAS 28115); ibid, 5 Aug 2003, G.-M. Li, T.-Z. Wei and Q.-B. Wang W03-10 (HMAS 85224); ibid, 6 Aug 2003, M. Li, T.-Z. Wei, Q.-B. Wang and G.-M. Li W03-13 (HMAS 85230); ibid, Menglun Town, Xishuangbanna Tropical Botanical Garden, 1 Aug 2004, M. Li and B.-H. Tang T0451 (HMAS 96501), M. Li and B.-H. Tang T0452 (HMAS 96492); ibid, 2 Aug 2004, M. Li and B.-H. Tang T0459 (HMAS 86660); ibid, 5 Aug 2004, A.-Y. Li and B.-H. Tang T0474 (HMAS 96500), A.-Y. Li and B.-H. Tang T0476 (HMAS 96494), A.-Y. Li and B.-H. Tang T0477 (HMAS 86668); ibid, 10 Aug 2004, M. Li and B.-H. Tang T04106 (HMAS 96517); Xundian, Xiaodianwei Village, 26 Jul 2004, Y.-B. Wu and B.-H. Tang T0410 (HMAS 96488), Y.-B. Wu and B.-H. Tang T0409 (HMAS 96671); Qujing, 20 Aug 1990, Z.-L. Yang (HKAS 23956); Jingdong, alt. 1650 m, 21 Aug 1991, P.-G. Liu 992 (HKAS 23958); Jiangcheng, Niuluo River, alt. 1400 m, 7 Aug 1991, Z.-L. Yang 1443 (HKAS 23974); Simao, alt. 1400 m, 6 Aug 1994, M. Zang 12281 (HKAS 28138); Menghai, Nannuo Mountains, alt. 1500 m, 8 Aug 1994, M. Zang 12289 (HKAS 28142); ibid, alt. 1200 m, 8 Aug 1994, Doi, Y. 80 (HKAS 28286); ibid, 15 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 214 (HMAS 85450); Jinghong, alt. 900 m, 14 Aug 1997, M. Zang 12809 (HKAS 30671); Binchuan, Jizu Mountains, 5 Aug 1989, Y.-C. Zong and Y. Li 104 (HMAS 59795); ibid, 23 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 424 (HMAS 78417). Sichuan: Dechang, Badong Town, 16 Aug 2003, Q.-B. Wang and S.-Z. Fu W03-48 (HMAS 84727), T.-Z. Wei and L. Jiao W03-43 (HMAS 79718); ibid, 15 Aug 2003,

H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-35 (HMAS 84728); ibid, Nanshan Town, 15 Aug 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao W03-42 (HMAS 85231); Miyi, alt. 2000 m, 27 Jul 1986, M.-S. Yuan 1176 (HKAS 18356); Tongjiang, Ahe Town, 21 Jul 1996, M.-S. Yuan 2260 (HKAS 30688); Pujiang, 18 Aug 2002, B. Wang 200240 (HMAS 83596). GUIZHOU: Yinjiang, Fanjing Mountains, alt. 1000 m, Aug 1983, X.-L. Wu 945 (HKAS 14307). Hainan: Danxian, 28 May 1988, G.-Y. Zheng (HMIGD 14647); Qiongshan, alt. 150–200 m, in group, 2 Jun 1988, T.-H. Li (HMIGD 14094); Wanning, 22 May 1988, T.-H. Li (HMIGD 13880). Fujian: Sanming, 1984, H.-Z. Li 175 (HMAS 51771); Wuyi Mountains, 1 VI 1998, X.-L. Mao 9422 (HMAS 74808). Taiwan: Mingtan, 23 Aug 1994, C.-M. Chen 830178 (HKAS 30319).

Termitomyces microcarpus is one of the smallest species of the genus and grows from the debris of the termite's comb, thus differing from other taxa of the genus (Batra & Batra 1967, Bels & Patarageteit 1982, Collins 1982, Pegler & Vanhaecke 1994, Hudler 1998). According to previous reports, the pileus of *T. microcarpus* is usually 1.0–2.5 cm diam., occasionally up to 3.6 cm (Otieno 1966, Pegler & Rayner 1969, Natarajan 1976, Heim 1977, Pegler 1977, 1986, Pegler & Piearce 1980, Van der Westhuizen & Eicker 1990, Pegler & Vanhaecke 1994, Turnbull & Watling 1999). The pileus of most collections cited here is 1.0–3.2 cm diam. with two exceptions (HMAS 84727 and 84728) from Sichuan Province, of which the pileus is up to 4.2 cm diam. and no termite nests were found below them.

Termitomyces microcarpus resembles other small *Termitomyces* species, such as *T. medius*, *T. radicatus* and *T. tylerianus*, but is distinguished by the absence of a pseudorhiza (Otieno 1969, Pegler & Rayner 1969, Natarajan 1976, Heim 1977, 1986, Pegler & Piearce 1980, Van der Westhuizen & Eicker, 1990, Pegler & Vanhaecke 1994, Turnbull & Watling 1999). Some basidiomata of *T. microcarpus* have root-like stipe bases which are easy to be mistaken for pseudorhizae, so differentiation of these small *Termitomyces* species mostly depends on original ecological records. Further, the species often grows in very large numbers.

Termitomyces microcarpus has a long list of synonyms. Singer (1945) divided the species from *Termitomyces* on the absence of a true pseudorhiza, making it the type species of *Podabrella*. However, *Podabrella* was rejected by Frøslev et al. (2003) on the basis of a sequence analysis of nrDNA-LSU and mtrDNA-SSU. Pegler (1977) included three African species, *T. badius*, *T. narobiensis* and *T. orientalis*, which also lack true pseudorhiza, with *T. microcarpus*, and later *T. indicus* was added by Pegler & Vanhaecke (1994). Yang (2000) examined type material of *Hiatula tonkinensis* from Vietnam and confirmed synonymy under *T. microcarpus*.

Termitomyces microcarpus is one of the most common species within the genus and is widely distributed in central and southern Africa (Otieno 1966, Heim 1977, Pegler 1977, Pegler & Piearce 1980, Piearce 1987, Van der Westhuizen & Eicker 1990) and South and Southeast Asia (Natarajan 1976,

Pegler 1986, Pegler & Vanhaecke 1994). The symbiotic associates include *Odontotermes badius*, *O. transvaalensis* (Sjöstedt) and *O. vulgaris* (Haviland) in Africa (Piearce 1987, Van der Westhuizen & Eicker 1990), and *O. malaccensis*, *O. redemanni* (Wasmann) and *Ancistrotermes* spp. in Asia (Pegler & Vanhaecke 1994). In China, *T. microcarpus* was found to the south of Yangtze River (Wei & Yao 2003) and symbiotic with *M. barneyi* (Lu et al. 2000).

Termitomyces striatus (Beeli) R. Heim, Arch. Mus. Hist. Nat. Paris, sér. 6, 18: 140 (1942).

≡ *Schulzeria striata* Beeli, Bull. Jard. Bot. État. 15: 29 (1938).

Pileus 4.2–8.0 cm diam., applanate with a small and bluntly pointed perforatorium (up to 4 mm high); surface pale greyish brown at centre, elsewhere white to pale grey, smooth, glabrous; margin straight, striate and splitting radially. Lamellae free, 3.0–5.0 mm wide, white to pinkish; crowded, with lamellulae. Stipe 4.5–10.0 × 0.3–0.6 cm, central, cylindrical; surface white, smooth and glabrous; solid, fibrous, of longitudinally parallel hyphae, thin-walled, hyaline, 2.0–20 μm diam. Pseudorhiza up to 28 cm long, cylindrical, terminating in contact with symbiotic termite comb; surface white, longitudinally striate; solid and fibrous, of parallel to subparallel hyphae, thin-walled and hyaline, 3.0–25 μm diam. Partial veil membranous, fragile, absent when mature. Context 3.0–5.0 mm thick under perforatorium, white, fleshy, of inflated hyphae, thin-walled and hyaline, normal hyphae 2.0–8.0 μm diam., inflating to 30 μm. Basidiospore deposit pinkish. Basidiospores 5.5–8.0 × 3.5–5.5 μm, ovoid to ellipsoid; thin-walled and hyaline. Basidia 17.0–28 × 6.0–8.5 μm, clavate, bearing four sterigmata; thin-walled and subhyaline. Lamella edge heterogeneous. Cheilocystidia 17.0–30 × 7.0–15 μm, clavate to pyriform; thin-walled and hyaline. Pleurocystidia 17.0–35 × 8.0–16.0 μm, similar to cheilocystidia, rare. Hymenophoral trama 60–80 μm, of thin-walled, hyaline hyphae, 4.0–20 μm diam. Subhymenial layer up to 10.0 μm wide, of repent hyphae, 2.0–5.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, thin-walled, 2.0–5.0 μm diam.

Specimens examined: CHINA: Yunnan: Mengla, Menglun Town, on termite subterranean nest at roadside, 6 Aug 2003, M. Li, T.-Z. Wei, Q.-B. Wang and G.-M. Li W03-12 (HMAS 79892); ibid, 9 Aug 1999, X.-L. Mao, H.-A. Wen and S.-X. Sun 40 (HMAS 63534); Xishuangbanna Tropical Botanic Garden, on termite nest, 8 Aug 2003, G.-R. Hu and T.-Z. Wei W03-26 (HMAS 88329); ibid, 3 Aug 2004, A.-Y. Li T0464 (HMAS 98979), B.-H. Tang and A.-Y. Li T0468 (HMAS 98981), A.-Y. Li and B.-H. Tang T0469 (HMAS 96675); ibid, 8 Aug 2004, M. Li and B.-H. Tang T0498 (HMAS 96489), M. Li and B.-H. Tang T04101 (HMAS 96490), M. Li and B.-H. Tang T04102 (HMAS 96498); Kunming, purchased in local market, 16 Aug 2004, B.-H. Tang T04116 (HMAS 98983).

Termitomyces striatus was made the type species of the genus by Heim (1942). The species is characterized by medium-sized basidiomata, small and pointed

perforatorium and white pseudorhiza (Heim 1942, 1977, Pegler 1977, Van der Westhuizen & Eicker 1990, Pegler & Vanhaecke 1994, Turnbull & Watling 1999). The species is very similar to *T. aurantiacus* but lacks a brightly colored pileus and the pileus is usually white, cream or pale grey. *Termitomyces striatus* grows from the nests of *Ancistrotermes*, *Odontotermes* and *Pseudacanthotermes* in Africa and in south and south-east of Asia (Heim 1977, Van der Westhuizen & Eicker 1990, Pegler & Vanhaecke 1994). In China, the species was reported to be symbiotic with *Macrotermes* spp. and *Pseudacanthotermes* spp. in Sichuan by Ying & Zang (1994) and Yuan & Sun (1995), but the distribution of this species in China is restricted to Yunnan according to this study.

Termitomyces tylerianus Otieno, Proc. E. Afr. Acad. 2: 116 (1966) ["1964"].

Pileus 1.0–2.0 cm diam., applanate with a small and sharply pointed perforatorium; surface brown at centre, pale yellow elsewhere, smooth and glabrous, finely striate radially; margin straight, splitting radially. Lamellae free, 1.0–2.0 mm wide, pinkish; crowded, with lamellulae. Stipe 3.0–4.0 × 0.2–0.3 cm, central, cylindrical; surface white, smooth and glabrous; solid and fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, 3.0–20 μm diam. Pseudorhiza 5.0 cm long, very slender, in contact with symbiotic termite comb; surface white to greyish white; solid, firbous, of longitudinally subparallel hyphae, thin-walled and hyaline, 5.0–15.0 μm diam. Partial veil absent. Context narrow, white, fleshy, of inflated hyphae, thin-walled and hyaline, 3.0–5.0 μm diam. normally, and inflating to 35 μm. Basidiospore deposit pinkish. Basidiospores 5.0–7.0 × 3.5–4.5 μm, ovoid to ellipsoid; thin-walled, subhyaline. Basidia 15.0–25 × 5.5–8.0 μm, clavate, bearing four sterigmata; thin-walled and sybhyaline. Lamella edge damaged, cheilocystidia not found. Pleurocystidia not found. Hymenophoral trama regular, 80 μm wide, of thin-walled and hyaline hyphae, 5.0–18.0 μm diam. Subhymenial layer up to 10.0 μm wide, of branched and repent hyphae, 2.0–5.0 μm diam. Pileipellis a repent epicutis of narrow, radial hyphae, thin-walled, 3.0–5.0 μm diam.

Specimens examined: CHINA: Yunnan: Mengla, Menglun Town, Xishuangbana Tropical Botanic Garden, 23 Aug 1990, Z.-L. Yang 1146 (HKAS 23290). Guangdong: Qujiang, alt. 500 m, growing in group on termite nest in broad-leaved forest, 28 Jul 1985, T.-H. Li (HMIGD 8667).

Termitomyces tylerianus was described by Otieno (1966) on the basis of specimens from Kenya. The species is one of the small species of *Termitomyces* and differs from *T. microcarpus* by the presence of a pseudorhiza. Compared with other small *Termitomyces* species with pseudorhizae, such as *T. medius* and *T. radicatus*, the pseudorhiza of *T. tylerianus* is longer and thinner and, moreover, the basidiomata of *T. tylerianus* are more slender than that of *T. medius*. A lack of collection details would make identification of *T. tylerianus* difficult.

Discussion

Among the 26 taxa of *Termitomyces* and six taxa of *Sinotermitomyces* reported in China (see Table 1), 11 of them are confirmed by this study as described above, whilst nine of them, including *T. albiceps*, *T. badius*, *T. cylindricus*, *T. macrocarpus* and five names in *Sinotermitomyces*, are synonyms of other *Termitomyces* names and three, namely *T. fuliginosus*, *T. medius* and *T. robustus*, were based on misidentification of collections as revealed by observation of original specimens by the present authors. *Termitomyces letestui* and *T. schimperi* are excluded from Chinese records because of significant differences between their Chinese and original descriptions. *Termitomyces albuminosus*, synonym of *Leucocoprinus cepistipes* (Sowerby) Pat. (see Pegler, 1986), was misapplied to Chinese records. *Sinotermitomyces meipengianus* is excluded based on examination of the type material (HKAS 43208), which is not *Termitomyces*, but a species of another genus, possibly in a group close to *Xerula* Maire and *Oudemansiella* Speg. The distribution in China of the remaining five taxa, *T. mammiformis* f. *albus*, *T. radicatus*, *T. spiniformis*, *T. striatus* f. *griseus* and *T. striatus* f. *ochraceus*, are unconfirmed by the lack of supporting specimens.

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